ADDITIONAL RECORDS OF PERMIAN BRACHIOPODS FROM NEAR RAT BURI, THAILAND

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The Permian brachiopod fauna of three localities from northern Peninsular Thailand is documented and new records are described. Two new subgenera of *Neochonetes* Muir-Wood 1962 are recognised and named: *Neochonetes (Nongtaia)* and *Neochonetes (Zechiella)*. The new species *Neochonetes (Nongtaia) taoni* is described. The ages of the Permian brachiopod faunas of Peninsular Thailand are reviewed and the assemblages described herein are referred to the Ufimian (=Roadian) stage.

Key words: Brachiopoda, Permian, Peninsular Thailand, Rat Buri Limestone, *Neochonetes*.

BRACHIOPODS are often abundant in the Permian marine fossil faunas of Peninsular Thailand. The collections described herein were briefly reported on by Baird et al. (1993) and Baird & Bosence (1993) based on initial determinations made by the present author. Baird et al. (1993) noted that the brachiopods identified for their study were from three localities and they grouped the three assemblages together for purposes of biostratigraphy. The present study separates the three assemblages, illustrates the species present and provides descriptions of the new records.

STRATIGRAPHY AND LOCALITIES

The Permian stratigraphy of Peninsular Thailand consists of a complex of siliclastic rocks, at times with prominent lithic fragments, overlain by the extensive Rat Buri Limestone.

The stratigraphy of the siliclastic sedimentary sequence is complex. An elaborate and confusing series of names has been applied to various stratigraphical sections from numerous geographical regions of the outcrop as summarised in the comprehensive reports by Stokes (1975) and Raksaskulwong & Wongwanich (1993, 1994). Portion of the historical use of various names is summarised in Table 1, the sources for which are Raksaskulwong & Wongwanich (1993: 5 and 1994: 112–114). The Kaeng Krachan (or Phuket) Group includes horizons informally known as the 'pebbly mudstones'. Considerable debate has occurred concerning the depositional environment of the 'pebbly mudstones' with some authors favouring a debris flow and turbidity current model of deposition (eg. Mitchell et al. 1970; Garson et al. 1975; Sawata et al. 1975; Altermann 1986) while others favour a glacial origin or influence on the sequence (eg. Stauffer 1983; Stauffer & Mantajit 1981; Metcalfe 1985, 1990, 1993, 1995; Ingavat-Helmcke & Helmcke 1994; Mantajit 1978, 1999).

The Rat Buri Limestone, deposited in a shelf or platform setting, overlies the Kaeng Krachan Group, either unconformably (Brown et al. 1951) or conformably (Bunopas 1976), and may interdigitate with the top beds of the Kaeng Krachan Group (Stokes 1975). Two small assemblages described herein were collected from quartzites from immediately below the carbonate sequence.

The three assemblages documented herein were collected by Dr Angus Baird, then of the Department of Geology, Royal Holloway and Bedford New College, University of London, Surrey, England, during 1989, who also provided the following locality data (Figs 1, 2).

Assemblage A1: Khao Nong Ta On—from a prominent brachiopod rich horizon at the top of the lower siliclastic sequence, just below the Rat Buri Limestone.

Assemblage B1: Khao Sam Ngan—from a locality midway in the carbonate section, Rat Buri Limestone.

Assemblage C1: Khao Bat Kwang—from beds immediately above a brachiopod rich horizon at the top of the siliclastic sequence, just below the Rat Buri Limestone.

Mitchell et al. 1970		Piyasin 1976		Garson et al. 1975		Pitakpaivan & Mantajit 1981		Raksaskulwong & Wongwanich 1993	
Rat Buri Limestone		Rat Buri Limestone		Rat Buri Limestone		Rat Buri Group		Rat Buri Group	
Phuket Group	Upper Fm with Bryozoa Lower Fm	Kaeng Krachan Group	Khao Chao Fm Khao Phra Fm Huai Phu Noi Fm	Phuket Group	Upper Fm with Bryozoa and brachiopods Lower Fm	Phuket or Kaeng Krachan Group	Ko Yao Noi Fm	Kaeng Krachan Group	Khao Phra Fm Ko He Fm Spillway Fm Khao Wang Kradot Fm

Table 1. Names applied to stratigraphical units below the Rat Buri Limestone.

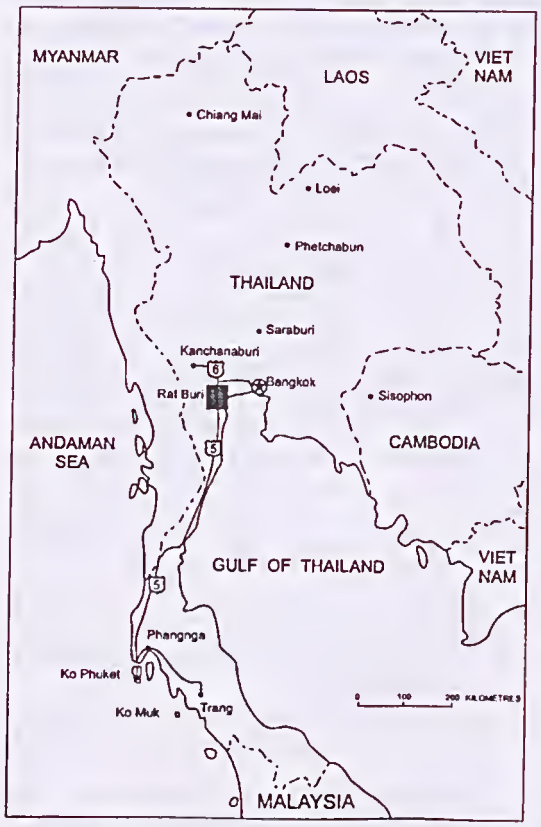


Fig. 1. Location map of the Rat Buri Area of north Peninsula Thailand.

PREVIOUS BRACHIOPOD FAUNAL STUDIES OF PENINSULAR THAILAND AND THEIR AGES

Brachiopod faunas have previously been described or illustrated from the Kaeng Krachan Group (including the pebbly mudstones) by Hamada (1960), Garson et al. (1975) and Waterhouse (1981a, 1982). Two distinct faunas have been documented. The apparently older fauna described by Hamada (1960) and Waterhouse (1982) consists of species of the genera *Arctitreta*, *Komukia*, *Bandoproductus*, *Rhynchopora*, *Sulciplica*, *Spirelytha*, *Lamniplica* and *Elasmata*. Originally assigned to the Carboniferous (Hamada 1960) the fauna was later assessed as Late Asselian (Waterhouse 1982). While lacking such characteristic cold water genera as the bivalve genus *Eurydesma*, five of the constituent genera out of nine (*Arctitreta*, *Bandoproductus*, *Rhynchopora*, *Sulciplica* and *Spirelytha*) are shared with Late Asselian? or Tastubian (Early Sakmarian) and Sterlitamakian (Late Sakmarian) faunas of Australia (Archbold & Shi 1995; Shi & Archbold 1995). A sixth genus (*Lamniplica*) is shared with comparable faunas from Peninsular India (in addition to *Bandoproductus* and a possible *Rhynchopora*)—see Archbold et al. (1996). Briggs (1998) provides a detailed analysis of the genus *Bandoproductus* and noted the wide variability of the Thailand species described by Hamada (1960) and Waterhouse (1982). On

balance, a Late Asselian or more likely, a Tastubian age is the preferred age estimate for this fauna.

A possibly allied fauna of Sterlitamakian age, from Langkawi Island, Peninsular Malaysia was briefly described by Shi et al. (1997). Several species of the Malaysian assemblage (eg. those of *Bandoproductus*, *Rhynchopora*, *Sulciplica* and *Spirelytha*) are close to those described by Waterhouse (1982) but a martiniid is present in the Langkawi fauna. Although referred to *Spinomartinia* by Shi et al. (1997), confirmation of the presence of the external ornament of

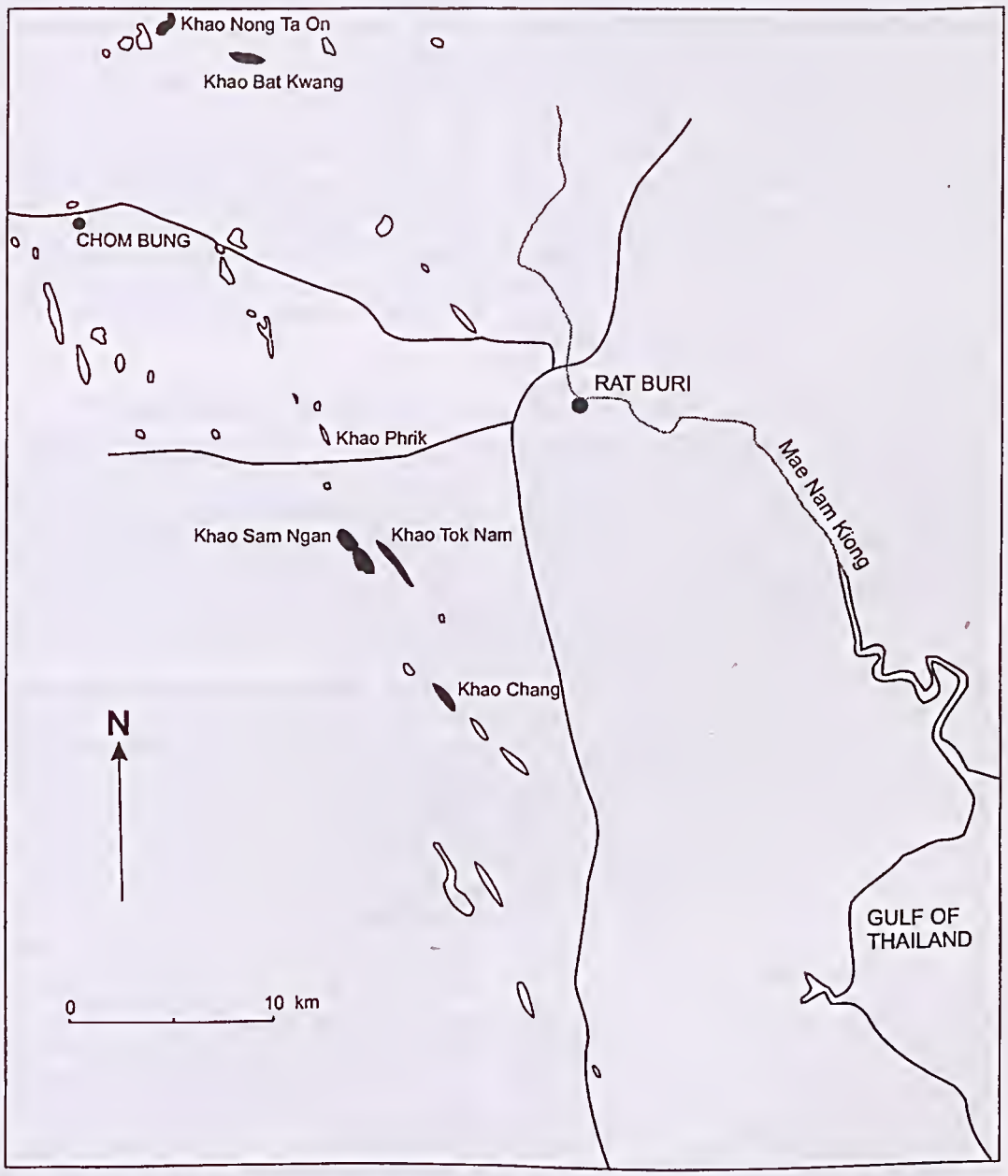


Fig. 2. Map of the Rat Buri Area showing outcrops of Rat Buri Limestone. Named outcrops are in black.

fine spinules is required for confident recognition of the genus (Waterhouse 1981a: 107). A Late Sakmarian or early Artinskian fauna from the Baoshan block, western Yunnan (Fang 1994) also includes *Bandoproductus* and a possible *Sulciplica* in addition to *Globiella*.

A younger, much more diverse, fauna has been mentioned by Young & Jantaranipa (1970), partially figured by Garson et al. (1975) and described by Waterhouse (1981a). The fauna, from beds high in the Ko Yao Noi Formation, 'could be Sakmarian or as young as Baigendzhinian' although 'likely to be Sakmarian' according to Waterhouse (1981a: 124). The fauna includes representatives of genera that characterise the Upper Byro Group of the Carnarvon Basin, Western Australia, such as *Demonedys*, *Dyschrestia*, *Retimarginifera*, *Spiriferella* and *Spirelytha* and hence suggests a younger age than Sakmarian (Sterlitamakian and Aktastinian in the sense of Waterhouse, 1981a). Also noteworthy are the numerous generic links with the brachiopod faunas of the lower Rat Buri Limestone (Waterhouse 1981a: 120) although species are distinctive. In view of the recent modifications to the ages assigned to the Western Australian late Early Permian stratigraphical units (ie. the recognition of an extended Kungurian record) as discussed by Archbold (1998a, 1998b) and the current views on the age of the brachiopod faunas of the Peninsular Rat Buri Limestone (see below) it appears increasingly likely that the upper Kaeng Krachan fauna described by Waterhouse (1981a) may be Late Artinskian (Baigendzhinian) in age.

The brachiopod faunas of the Rat Buri Limestone of peninsula Thailand (the latter geographical region defined by Fontaine et al. 1994a) were first recorded by G. A. Cooper in Brown et al. (1951: 35) and have been progressively well described by Waterhouse & Piyasin (1970), Yanagida (1971) and Grant (1976) with ages also discussed by Piyasin (1975), Waterhouse (1973, 1976, 1981b) and Yanagida (1984). All of these authors recognised to some degree a mid-Permian (Kungurian to Late Ufimian = Roadian in the current terms) element to the faunas, although the then knowledge of the mid-Permian subdivisions of the timescale hampered precise dating. Links were recognised with the Bitauni fauna of Timor, the Amb fauna of the Salt Range, Pakistan and the Road Canyon Formation of West Texas, all of mid-Permian age. Recent discussions on the age of several of these units indicates an age range of Bolorian (Kungurian) and Kubergandian (Ufimian including Roadian) as indicated by Fontaine et al. (1994), Angiolini et al. (1998) and Iqbal et al. (1998). In terms of the timescale used by Archbold (1998a, 1998b) an Ufimian age is assigned by me to the Peninsular Rat Buri Limestone brachiopod faunas. Permian crinoids from the Rat Buri Limestone are, in general terms, also consistent with this age assignment (cf. Webster & Jell 1993; Racey et al. 1994) as are elements of the distinctive coral faunas of Peninsular Thailand (Fontaine et al. 1994b). A correlative fauna is known from Irian Jaya (Indonesia) as described and discussed by Archbold (1981a, 1992) and Archbold et al. (1982) and commented on by Fontaine et al. (1994b). It should be noted that studies based on small foraminiferids and other microfloras and faunas often indicate ages younger than Ufimian (Kubergandian–Roadian) for outcrops of the Rat Buri Limestone (eg. see Baird et al. 1993; Baird & Bosence 1993; Dawson et al. 1993; Fontaine et al. 1994). However, the brachiopod faunas come from low in the Limestone which 'has not yielded microfaunas or (has) provided very poor microfaunas without stratigraphical meaning' (Fontaine et al. 1994: 136).

THE NEW COLLECTIONS

The species identified herein are listed in Table 2. Each assemblage is identified separately. Preservation of the specimens is as silicified replacements and minute surface details and features such as punctae are preserved. Figured specimens are housed in the collections of the Museum of Victoria, Melbourne (NMV P). All species are figured but only new species and records are described.

The assemblages from Khao Nong Ta On and Khao Sam Ngan share the species *Orthotichia waterhousei*, *Waterhouseiella speciosa* and *Spiriferellina adunctata*. This indicates that the two assemblages can be correlated. The additional species of the two assemblages, consisting of *Marginifera otaria*, *Cleiothyridina seriata*, *Hustedia ratburiensis* and *Notothyris triplax*, confirm a correlation with the Rat Buri Limestone faunas as described by Waterhouse & Piyasin (1970), Yanagida (1971) and Grant (1976). Of interest are the new records of chonetids *Neochonetes (Nongtaia) taoni* sp. nov. and *Quinquenella*? sp., from Khao Nong Ta On. These indicate that the Rat Buri faunas have yet to yield their full diversity.

The assemblage from Khao Bat Kwang is more difficult to assess. The orthotetid fragments are not diagnostic and the *Trigonotreta* specimen is the first record of the genus from Thailand although it is considered by the present author that several of the specimens, assigned to *Neospirifer*

sterlitamakensis (Gerasimov, 1929) by Waterhouse (1981a) from the Kaeng Krachan Group, Ko Yao Noi Formation, belong to a group of *Trigonotreta* species well developed in the Sterlitamakian to Ufimian faunas of Western Australia (Archbold & Thomas 1986) and elsewhere in peripheral Gondwanan regions. *Trigonotreta* has yet to be identified from the Rat Buri Limestone proper and hence may indicate a somewhat older age for the Khao Bat Kwang occurrence.

SYSTEMATIC PALAEONTOLOGY

Order CHONETIDA Nalivkin, 1979

Suborder CHONETIDINA Muir-Wood, 1955

Superfamily CHONETOIDEA Bronn, 1862

Family RUGOSOCHONETIDAE Muir-Wood, 1962

Subfamily RUGOSOCHONETINAE Muir-Wood, 1962

Genus **Neochonetes** Muir-Wood, 1962

Subgenus **Neochonetes (Nongtaia)** subgen. nov.

Type species. *Neochonetes (Nongtaia) taoni* sp. nov.

Etymology. Derived from the name of Khao Nong Ta On.

Diagnosis. Similar to *Neochonetes (Neochonetes)* but shells small, subquadrate, with relatively narrow, distinct suleus, distinct dorsal fold, distinct ornament of coarse capillae increasing in number by bifurcation.

Khao Nong Ta On	Khao Sam Ngan	Khao Bat Kwang
Orthotichia waterhousei	*Orthotichia waterhousei*	--
orthotetid fragments	--	orthotetid fragments
Waterhouseiella speciosa	*Waterhouseiella speciosa*	--
Neochonetes (Nongtaia) taoni	--	--
Quinquenella? sp.	--	--
--	*Marginifera otaria*	--
--	spinose productid	--
--	*Cleiothyridina seriata*	--
--	--	*Trigonotreta* sp.
Spiriferellina adunctata	*Spiriferellina adunctata*	--
Hustedia ratburiensis	--	--
--	*Notothyris triplax*	--

Table 2. Brachiopods from Khao Nong Ta On, Khao Sam Ngan and Khao Bat Kwang.

Discussion. The genus *Neochonetes* was discussed by Archbold (1981b: 111, 113) in terms of species composition and related species groups or stocks. One distinctive stock of mainly large species of Permian age was given the subgeneric name of *Sommeriella* Archbold (1982: 10) and the subgenus was widely indicated to be present throughout the Cimmerian Province, as tabulated by Archbold (1983) and listed for Western Australia by Archbold (1998b). Angiolini (1996) has added significantly to the knowledge of the mid-Permian species from the Karakorum.

The new material from Peninsular Thailand provides additional data on trends in the evolution of the *Neochonetes* group from the mid-Permian. Small species with distinct ornament, a subquadrate outline, a distinct and normally narrow ventral sulcus and corresponding dorsal fold appear in the Ufimian and Kazanian. In addition to the type species of *Neochonetes (Nongtaia)*, the species *Chonetes pinegensis* Kulikov (1974) from the Kazanian of the Pinega River, Russia (see also Likharev 1931: pl. 1, figs 15, 16; pl. 3, fig. 14, identified as *Chonetes carbonifera* Keyserling) and *Neochonetes* cf. *pinegensis* of Stepanov et al. (1975: pl. 1, figs 3, 4) from the Kazanian of the Kanin Peninsula are assigned to the new subgenus. The *Chonetes* sp. (Likharev 1913: pl. 3, figs 17a, 17b) from the Kazanian of the region of Novgorod, Russia, is also allied.

Other species tentatively assigned to *Neochonetes (Nongtaia)* include the Kazanian (Murgabian) species *Chonetes arabicus* (Hudson & Sudbury 1959: 26, pl. 3, figs 6–16; pl. 6, figs 14–18; see also Archbold & Burrett 1990: fig. 1A–C) from Oman and *Neochonetes asseretoi* Fantini Sestini (1964) from Iran, both on the basis of their small size, subquadrate outlines and distinct external ornament and ventral sulci. The relatively small species *N. (Sommeriella) hardmani* Archbold (1993) from the Late Permian (Djhulfian) of Western Australia is also allied to species of *Neochonetes (Nongtaia)*, but possesses a somewhat broader sulcus. It is provisionally transferred to the new subgenus.

Neochonetes (Nongtaia) taoni sp. nov.

Fig. 3A–O

Neochonetes sp. Archbold, in Baird et al. 1993: 245.
Neochonetes (Chonitella) (sic), Baird et al. 1993: 247.

Holotype. NMV P120374, a complete dorsal valve from Khao Nong Ta On.

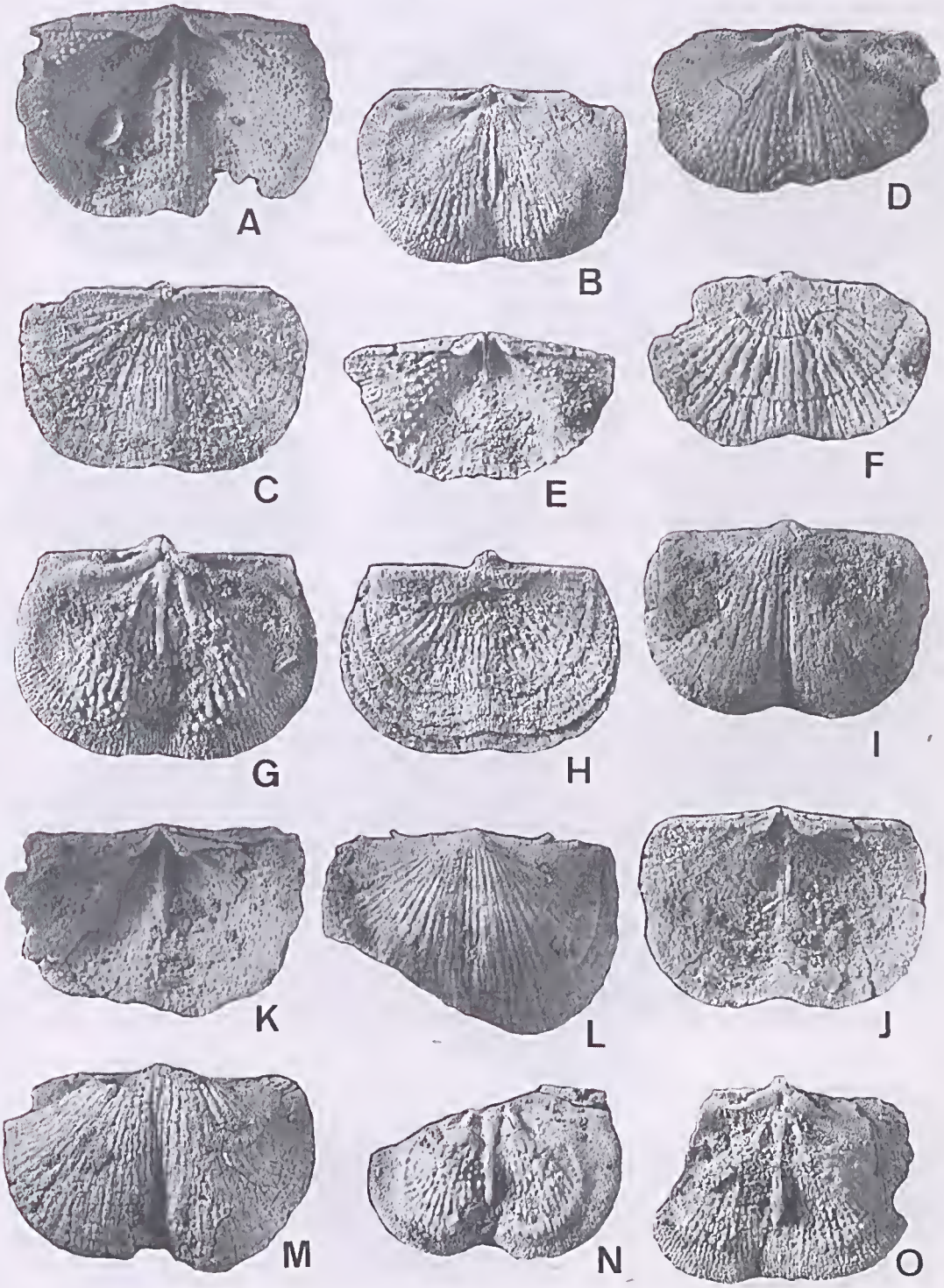
Paratypes. NMV P120375–NMV P120385, five ventral valves, one conjoined shell and five dorsal valves all from Khao, Nong Ta On.

Size ranges. Maximum width 6.1–13.2 mm; hinge width 6.1–11.5 mm; height of ventral valve 3.5–8.6 mm; height of dorsal valve 5.8–9.0 mm.

Description. Moderate sized *Neochonetes (Nongtaia)*. Ventral valve convex with distinct sulcus arising within one millimetre of umbo. Central valley of sulcus narrow anteriorly. Dorsal valve gently concave with distinct but low median fold. Greatest width of shell at about mid-length; at or close to hinge line in juvenile specimens. Exterior shell surface with relatively coarse capillae increasing in number anteriorly by bifurcation and occasional pronounced growth lines, the latter particularly at the anterior of mature shells. Ventral interarea low, dorsal interarea very low. Ventral umbo low, cardinal spines project at about 40° close to umbo, at low angle (about 25°) at extremities of hinge line. Teeth distinct, moderately thickened. Delthyrium distinct. Prominent ventral median septum arises under delthyrium, extends anteriorly for up to two-thirds of valve length. Muscle scars weakly impressed. Parallel vascular trunks developed in mature ventral valves. Anterior and lateral margins of mature ventral valve strongly papillose.

Cardinal process low, distinctly bilobed on interior face, weakly quadrilobed on exterior face. Prominent, small, deep alveolus at base of process. Socket ridges prominent, thickened; sockets deep, wide. Lateral septa distinct at maturity. Median septum arises close to alveolus, thickened at maturity, raised anteriorly, extends anteriorly up to two-thirds valve length. Brachial ridges distinct at maturity; develop and enlarge from radial rows of

Fig. 3. A–O, *Neochonetes (Nongtaia) taoni* sp. nov. A, NMV P120375, ventral valve, interior view, ×4.5. B, C, NMV P120376, dorsal valve, interior and exterior views, ×4.0. D, NMV P120377, dorsal valve, interior view, ×4.5. E, NMV P120378, ventral valve, interior view, ×8. F, NMV P120379, dorsal valve, interior and exterior views, ×4.5. G, H, Holotype, NMV P120374, dorsal valve, interior and exterior views, ×4.5. I, J, NMV P120380, ventral valve, exterior and interior views, ×4.5. K, NMV P120381, ventral valve, interior view, ×4.5. L, NMV P120382, shell, ventral view, ×4.5. M, NMV P120383, shell, ventral view, ×3.5. N, NMV P120384, dorsal valve, interior view, ×3.5. O, NMV P120385, dorsal valve, interior view, ×4.0. All from Khao Nong Ta On.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papillae. Anterior and lateral margins of dorsal valve interior with radiating rows of fine papillae. Posterior margins of dorsal valve interior smooth.

Discussion. *Neochonetes (Nongtaia) taoni* is readily distinguished from other speeies discussed above that are assigned to the new subgenus by means of its distinctive deep central valley normally developed in the sulcus. *N. (Nongtaia) arabicus* (Hudson & Sudbury, 1959) has less strongly developed internal features than the Thai species. The internal features of other related species from Northern European Russia are poorly known. The narrow sulcus of the new species is similar to that shown by several specimens of *Neochonetes (Sommeriella) irianensis* Archbold (1992: fig. 2K–L, O–P) from the Artinskian of Irian Jaya, which may represent an aneestral species to the new subgenus.

Subgenus **Neoehonetes (Zeehiella)** subgen. nov.

Type species. *Chonetes davidsoni* von Sehauroth (1856: 222, pl. 11, figs 1a–b) from the Mergelschiefer near Ilmenau, Germany.

Etymology. Derived from the name Zechstein.

Diagnosis. Small, thin shelled *Neochonetes* with obsoleseent radial capillae, suleus absent, internal structures poorly developed.

Discussion. *Neochonetes (Zechiella)* consists of a distinetive group of upper Permian speeies from the Zechstein Basin and possibly Armenia as diseussed briefly by Archbold (1981b: 113). With the formal naming of the subgenus *N. (Nongtaia)* it is also appropriate to name this seeond identifiable group of distinctive Upper Permian *Neochonetes.* Species assigned to *N. (Zechiella)* are the type species (see also Davidson 1880: 244, pl. 30, figs 1–2; Muir-Wood 1962: pl. 5, figs 28–29), *Chonetes woolacotti* Trechmann (1945: 346, pl. 15, figs 1–5b; see also Malzahn 1957: 99, pl. 10, figs 1–4) and *Chonetes kirkbyi* Trechmann (1945: 348, pl. 15, figs 6–9; see also Malzahn 1957: 102, pl. 10, figs 5–6; pl. 11, fig. 3), all from both the English and German Zechstein. An allied species from the Kazanian of Armenia, with poorly developed radial ornament and no development of the ventral sulcus is *Neochonetes armenicus* Sokolskaya (1965: 209, pl. 32, figs 1–3, in Ruzhentsev & Saryeheva 1965), a species with clearly demareated, flattened posterior lateral valve flanks.

Subfamily QUINQUENELLINAE Archbold, 1981c

Genus **Quinquenella** Waterhouse, 1975

Type species. *Quinquenella glabra* Waterhouse, 1975, from the Djhulfian of northwest Nepal.

Quinquenella? sp.

Fig. 4M

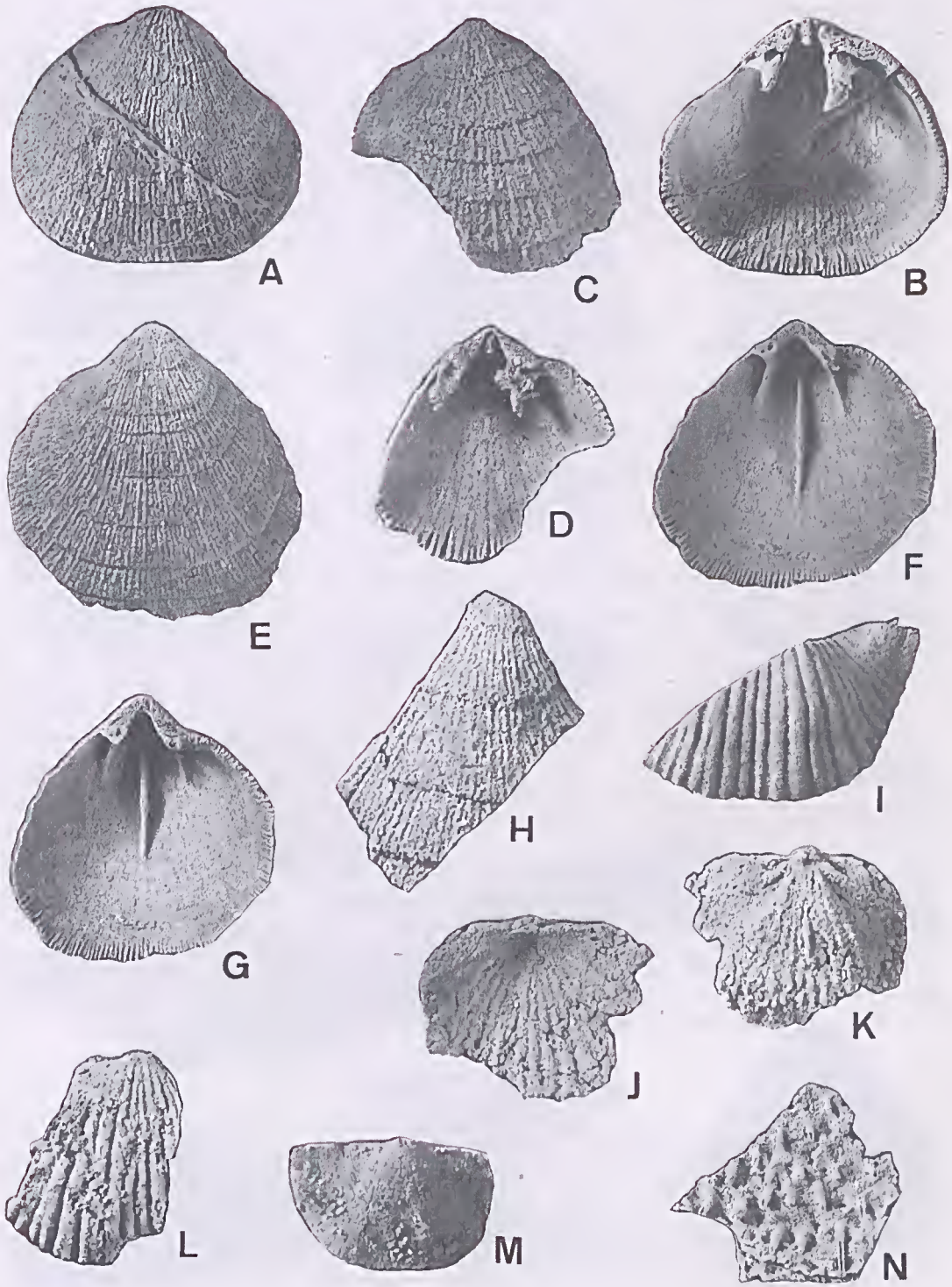
Material. A single juvenile ventral valve, NMV P120392, from the locality Khao Nong Ta On. The speeimen is 5.0 mm wide and 3.5 mm in length.

Discussion. Chonetoids lacking radial ornament are rare in the Permian of Peninsular Thailand, being restricted to *Costachonetina* Waterhouse (1981a), *Demonedys* Grant (1976) and *Tornquistia* Paeekelmann (1930) from the Rat Buri Limestone and *Demonedys* (assigned to *Tornquistia* by Waterhouse 1981a) from the Ko Yao Noi Formation of the Kaeng Krachan Group.

The single available specimen of *Quinquenella?* sp. cannot be assigned to any of the above genera in view of its flattened median portion of the ventral valve and its more semieireular outline. The outline of the speeimen is elosest to that of Thai speeimens of *Tornquistia* (Grant 1976: pl. 14, figs 1–10) but the latter do not possess a flattened median portion of the ventral valve.

Assignment of the specimen to *Quinquenella* can only be provisional due to the lack of information eoncerning the dorsal valve, however the genus is

Fig. 4. A–H, *Orthotichia waterhousei* Grant. A, B, NMV P120386, dorsal valve, exterior and interior views, ×4.5. C, D, NMV P120387, dorsal valve, exterior and interior views, ×4.5. E, G, NMV P120388, ventral valve, exterior, interior and tilted interior views, ×4.5. H, NMV P120389, fragment of ventral valve, exterior view, ×4.5. I–L, *Waterhouseiella speciosa* (Waterhouse & Piyasin). I, NMV P120409, ineomplete shell, ventral view, ×4.5. J, K, NMV P120390, dorsal valve, exterior and interior views, ×4.5. L, NMV P120391, incomplete shell, ventral view, ×4.5. M, *Quinquenella?* sp., NMV P120392, ventral valve, exterior view, ×6.5. N, productid fragment, NMV P120393, exterior view, ×4.5. H, J–L, N, from Khao Sam Ngan, remainder from Khao Nong Ta On.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known to occur from strata now considered to be of Kungurian age of Western Australia (Archbold 1981c) and Kungurian or probably Ufimian age of Irian Jaya (Archbold 1981d). The type species of *Quinquenella* is of Djhulfian (=Wuchiapingian) age from Nepal. All species assigned to *Quinquenella* possess very similar ventral valve morphology. The specimens assigned to *Micraphelia*? sp. by Ishii et al. (1972: 68, pl. 1, figs 2, 4–8) from the Upper Permian of Perlis, Malaysia, may be allied judging from the outlines of the specimens but dorsal internal details are lacking.

Order SPIRIFERIDA Waagen, 1883

Suborder SPIRIFERIDINA Waagen, 1883

Superfamily SPIRIFEROIDEA Waagen, 1883

Family SPIRIFERIDAE King, 1846

Subfamily TRIGONOTRETINAE Schuchert, 1893

Genus **Trigonotreta** Kocnig, 1825

Type species. Trigonotreta stokesii Koenig, 1825, from the Sakmarian of Tasmania.

Trigonotreta sp.

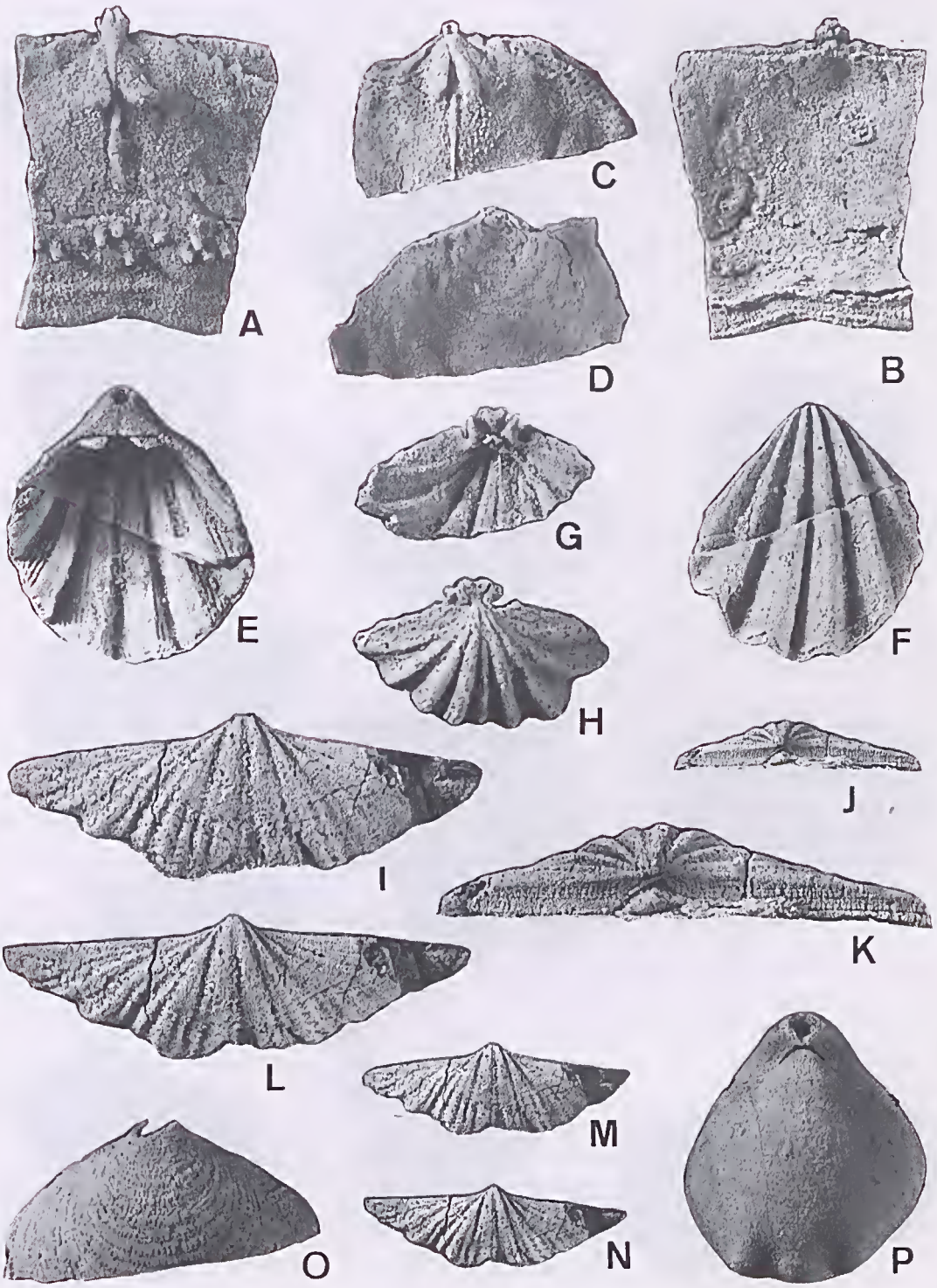
Fig. 51–N

Material. A single juvenile ventral valve, NMV P120398, from Khao Bat Kwang. The specimen is 38 mm wide and 12 mm in length.

Discussion. Apart from the mention of my provisional identification of *Trigonotreta* by Baird et al. (1993: 247) the generic name has not been applied previously to any species from Peninsular Thailand. Grant (1976: 213, pl. 60, figs 43–44) recorded a single dorsal valve fragment of *Neospirifer* Fredericks (1923) from the Rat Buri Limestone and Waterhouse (1981: 101, pl. 25, figs 3–5; pl. 26, figs 1–7) described a suite of specimens as *Neospirifer sterlitamakensis* (Gerasimov 1929) from Ko Yao Noi. Garson et al. (1975: pl. 3, figs 6, 10) had previously figured three mature specimens of *Neospirifer* that the present author has assigned to the subgenus *Neospirifer (Quadrospira)* (Archbold 1997: 214). The material described by Waterhouse (1981a) appears to fall into two groups—a true *Neospirifer* with fine, equidimensional costae (Waterhouse 1981: pl. 26, fig. 7) and a species with distinctive groups of three unequal costae and prominent, projecting growth lines as in a group of *Trigonotreta* species described from Tastubian to Ufimian strata of Western Australia (Archbold & Thomas 1986). All the Western Australia species possess relatively transverse juvenile stages of growth and hence are comparable with the new specimen, which is abraded and incomplete anteriorly. This group of *Trigonotreta* species is also known widely from peripheral Gondwanan regions such as Oman (Angiolini et al. 1997: fig. 15-12) and the Baoshan block, Yunnan (Shi et al. 1995: fig. 3-14; Shi et al. 1996: fig. 5c) from faunas of a Sakmarian age. True *Neospirifer sterlitamakensis* (Gerasimov 1929: 810, pl. 2, fig. 2) possesses fine, equidimensional costae and is better placed in *Neospirifer* as also shown by the specimen figured as *Spirifer fasciger* by Chernyshev (1902: 143, pl. 49, fig. 1a–b) and the specimen figured as *Spirifer striatus* var. *attenuatus* by Meller (1862: 66, pl. 2, fig. 4a–b) both assigned by Gerasimov to his new 'mutation'. The species was treated as a variety by Stepanov (1948: 41, pl. 7, fig. 12) who figured a well preserved juvenile shell from the Gzhelian of Bashkiria. Mironova (1967: 43, pl. 4, fig. 6) also figured a well preserved small ventral valve from the same region and noted that *Neospirifer sterlitamakensis* ranged from the Gzhelian to the Sterlitamakian inclusive.

The presence of a specimen of *Trigonotreta* at Khao Bat Kwang may indicate that the assemblage is slightly older than that of the other two localities discussed in this study.

Fig. 5. A–D, *Marginifera otaria* Grant. A, B, NMV P120394, incomplete dorsal valve, interior and exterior views, ×5.0. C, D, NMV P120395, incomplete dorsal valve, interior and exterior views, ×4.5. E–H, *Hustedia ratburiensis* Waterhouse & Piyasin. E, F, NMV P120396, ventral valve, interior and exterior views, ×4.5. G, H, NMV P120397, dorsal valve posterior portion, interior and exterior views, ×5.5. I–N, *Trigonotreta* sp., NMV P120398, juvenile ventral valve, exterior, tilted exterior and interarea views, ×1 and ×2. O, *Cleiothyridina seriata* Grant, NMV P120399, ventral valve, exterior view, ×5.0. P, *Notothyris triplax* Grant, NMV P120400, shell, dorsal view, ×4.5. A–D, O, P, from Khao Sam Ngan; E–H, from Khao Nong Ta On; I–N, from Khao Bat Kwang.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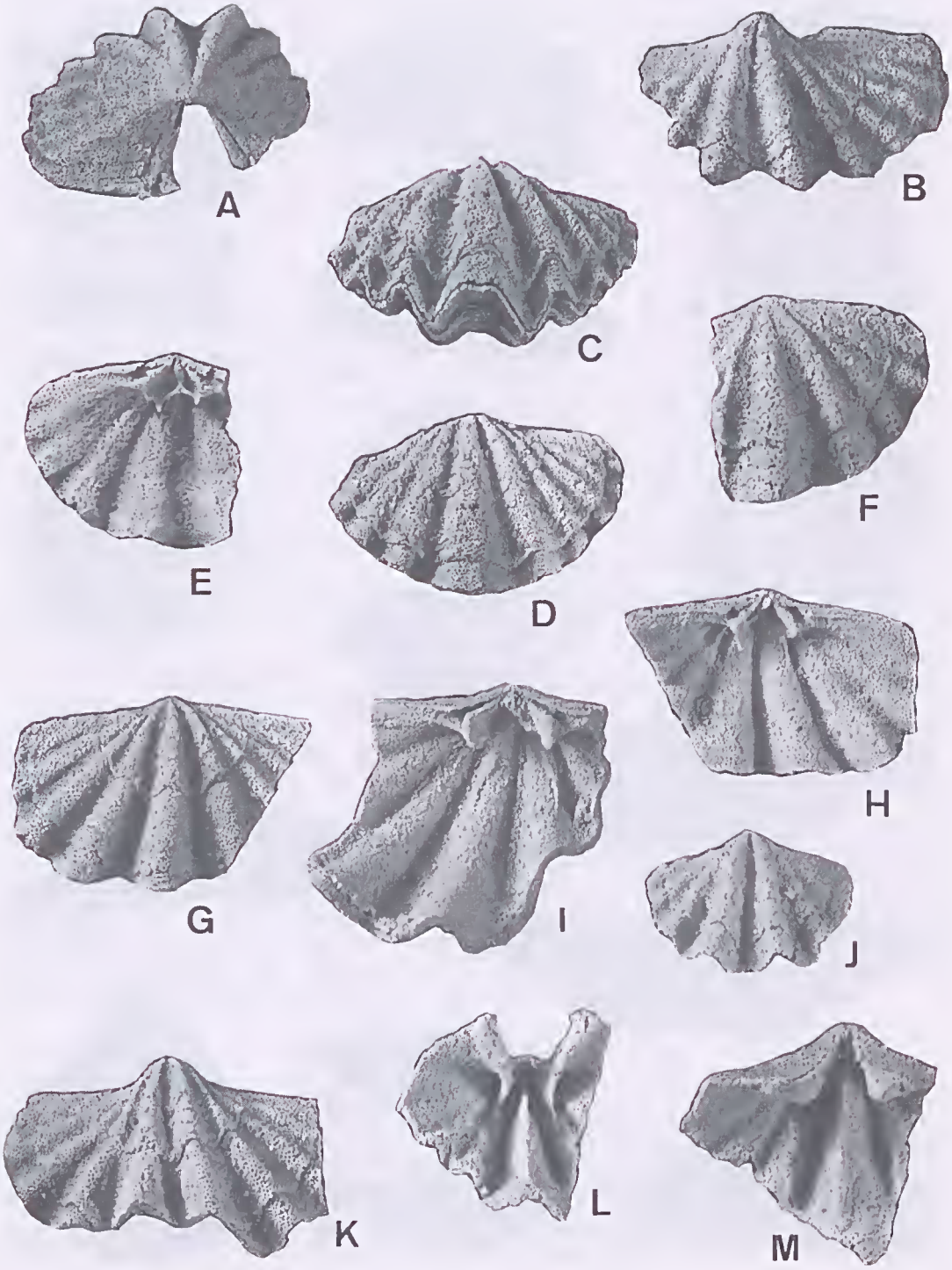
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Fig. 6. A–M, *Spiriferellina aduncta* Waterhouse & Piyasin. A, B, NMV P120401, ventral valve, posterior and ventral views, ×4.5. C, D, NMV P120402, incomplete shell, anterior and dorsal views, ×4.5. E, F, NMV P120403, dorsal valve, interior and exterior views, ×5.0. G, H, NMV P120404, dorsal valve, exterior and interior views, ×5.0. I, NMV P120405, dorsal valve, interior view, ×5.0. J, NMV P120406, ventral valve, exterior view, ×7.0. K, NMV P120407, ventral valve, exterior view, ×5.0. L, M, NMV P120408, tilted interior view and interior view, ×5.0. I, J, from Khao Sam Ngan, remainder from Khao Nong Ta On.

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